

C L A I M S

[1] A developing method for subjecting a light-exposed resist film disposed on a substrate to a developing process by a developing solution and a rinsing process by a rinsing liquid, the method comprising:

supplying a chemical liquid, which contains a resist curing aid contributory to curing of a resist film remaining on the substrate, onto a surface of the substrate, in a state where the resist film on the substrate is wet with the developing solution or rinsing liquid; and then radiating predetermined high energy rays onto a surface of the substrate, thereby curing the resist film by a synergistic effect of the resist curing aid and the high energy rays thus radiated.

[2] The developing method according to claim 1, wherein the resist curing aid is water soluble, and the chemical liquid is a water solution.

[3] The developing method according to claim 1, wherein the resist curing aid is hydrophobic, and the chemical liquid is a hydrophobic organic solvent.

[4] The developing method according to any one of claims 1 to 3, wherein the method comprises starting supply of the developing solution onto the substrate, and, immediately thereafter, supplying the chemical liquid onto a portion of the substrate supplied with

the developing solution, and radiating the high energy rays onto a portion supplied with the chemical liquid.

[5] The developing method according to any one of claims 1 to 3, wherein the method comprises forming a puddle by supplying the developing solution onto the substrate, and then supplying the chemical liquid onto the puddle, and radiating the high energy rays onto a portion supplied with the chemical liquid.

[6] The developing method according to any one of claims 1 to 3, wherein the method comprises processing the resist film on the substrate by the developing solution, and then starting supply of the rinsing liquid onto the substrate, and, immediately thereafter, supplying the chemical liquid onto a portion of the substrate supplied with the rinsing liquid, and radiating the high energy rays onto a portion supplied with the chemical liquid.

[7] The developing method according to any one of claims 1 to 3, wherein the method comprises processing the substrate by the developing solution and the rinsing liquid, and then supplying the chemical liquid onto the substrate, in a state where the resist film on the substrate is wet with the rinsing liquid, and radiating the high energy rays onto a portion supplied with the chemical liquid.

[8] The developing method according to any one of claims 1 to 3, wherein the method comprises supplying

the chemical liquid to replace the developing solution or rinsing liquid on the substrate with the chemical liquid, and radiating the high energy rays onto a surface of the substrate.

5           [9] The developing method according to any one of claims 1 to 3, wherein the method comprises replacing the developing solution or rinsing liquid on the substrate with a water soluble organic solvent, and then replacing the organic solvent with the chemical  
10 liquid, and radiating the high energy rays onto a surface of the substrate.

          [10] The developing method according to any one of claims 1 to 9, wherein the chemical liquid contains a surfactant as an additive.

15           [11] The developing method according to any one of claims 1 to 10, wherein the rinsing liquid, which is supplied onto the substrate after a process by the chemical liquid, contains any one of a surfactant, a chemical liquid having a large contact angle relative  
20 to the resist film, and a chemical liquid having a contact angle equivalent to purified water and a small surface tension.

          [12] The developing method according to any one of claims 1 to 11, wherein the method comprises supplying  
25 the chemical liquid onto the substrate while rotating the substrate.

          [13] A developing method for subjecting a light-

exposed resist film disposed on a substrate to a developing process by a developing solution and a rinsing process by a rinsing liquid, the method comprising:

5           mixing the developing solution and a chemical liquid at a predetermined ratio to form a mixture liquid, and supplying the mixture liquid onto the substrate, wherein the chemical liquid contains a resist curing aid contributory to curing of a resist  
10 film remaining on the substrate after a developing reaction; and then radiating predetermined high energy rays onto a surface of the substrate, thereby concurrently performing a developing reaction of the resist film and curing of the resist film by a  
15 synergistic effect of the resist curing aid and the high energy rays.

[14] The developing method according to claim 13, wherein the method comprises supplying the mixture liquid onto the substrate while rotating the substrate.

20           [15] A developing method for subjecting a light-exposed resist film disposed on a substrate to a developing process by a developing solution and a rinsing process by a rinsing liquid, the method comprising:  
25           during a rinsing process, mixing a chemical liquid and a rinsing liquid at a predetermined ratio to form a mixture liquid, and supplying the mixture liquid onto

the substrate, wherein the chemical liquid contains a resist curing aid contributory to curing of a resist film remaining on the substrate after a developing reaction; then radiating predetermined high energy rays  
5 onto a surface of the substrate, thereby curing the resist film by a synergistic effect of the resist curing aid and the high energy rays; and then supplying only a rinsing liquid onto the substrate to wash out the mixture liquid from the substrate.

10 [16] The developing method according to claim 15, wherein the method comprises supplying the mixture liquid onto the substrate while rotating the substrate.

[17] The developing method according to any one of claims 12, 14, and 16, wherein the substrate is rotated  
15 at a rotational velocity of 4,000 rpm or less.

[18] The developing method according to any one of claims 1 to 17, wherein the high energy rays comprise ultraviolet rays, infrared rays, microwaves, heat rays, or electron rays.

20 [19] The developing method according to any one of claims 1 to 18, wherein the rinsing liquid comprises purified water.

[20] A developing apparatus comprising:

a rotatable spin chuck configured to hold a  
25 substrate having a light-exposed resist film disposed thereon;

a developing solution nozzle configured to supply

a predetermined developing solution for developing the resist film onto a surface of the substrate held by the spin chuck;

5 a rinsing nozzle configured to supply a rinsing liquid onto a surface of the substrate held by the spin chuck;

10 a chemical liquid nozzle configured to supply a chemical liquid onto a surface of the substrate held by the spin chuck, wherein the chemical liquid contains a resist curing aid contributory to curing of a resist film remaining on the substrate after a developing reaction;

15 a shifting mechanism configured to move the developing solution nozzle, the rinsing nozzle, and the chemical liquid nozzle relative to the substrate held by the spin chuck; and

a light radiation mechanism configured to radiate light having a predetermined wavelength onto a surface of the substrate held by the spin chuck.

20 [21] The developing apparatus according to claim 20, wherein the light radiation mechanism is configured to be moved relative to the substrate held by the spin chuck.

25 [22] The developing apparatus according to claim 20 or 21, wherein the developing solution nozzle has a structure elongated in one direction and configured to deliver the developing solution essentially as a strip

extending in a longitudinal direction thereof,

the chemical liquid nozzle has a structure elongated in one direction and configured to discharge the chemical liquid essentially as a strip extending in a longitudinal direction thereof, and

the developing solution nozzle and the chemical liquid nozzle are integrated in parallel with each other.

[23] The developing apparatus according to claim 20 or 21, wherein the rinsing nozzle has a structure elongated in one direction and configured to discharge the rinsing liquid essentially as a strip extending in a longitudinal direction thereof,

the chemical liquid nozzle has a structure elongated in one direction and configured to discharge the chemical liquid essentially as a strip extending in a longitudinal direction thereof, and

the rinsing nozzle and the chemical liquid nozzle are integrated in parallel with each other.

[24] The developing apparatus according to claim 22 or 23, wherein the light radiation mechanism comprises a casing elongated in one direction and having a slit to radiate light essentially as a strip extending in a longitudinal direction thereof, and a light source of a predetermined wavelength disposed in the casing, and

the casing and the chemical liquid nozzle are

integrated in parallel with each other.

[25] The developing apparatus according to claim  
20, wherein the chemical liquid nozzle comprises a  
casing elongated in one direction, which has a chemical  
5 liquid cell to store the chemical liquid therein, and a  
discharge port to discharge the chemical liquid  
essentially as a strip extending in a longitudinal  
direction thereof from the chemical liquid cell,

the light radiation mechanism comprises a casing  
10 elongated in one direction and having a slit to radiate  
light essentially as a strip extending in a  
longitudinal direction thereof, and a light source of a  
predetermined wavelength disposed in the casing, and

the casing of the chemical liquid nozzle and the  
15 casing of the light radiation mechanism are integrated  
in parallel with each other.

[26] The developing apparatus according to any one  
of claims 20 to 23, wherein the light radiation  
mechanism has a structure comprising a plurality of  
20 light sources arrayed at predetermined intervals  
lengthwise and breadthwise to uniformly irradiate an  
entire surface of the substrate held by the spin chuck  
with light having a predetermined wavelength.

[27] The developing apparatus according to any one  
25 of claims 20 to 23, wherein the light radiation  
mechanism comprises a casing elongated in one direction  
and having a slit to radiate light essentially as a



strip extending in a longitudinal direction thereof,  
and a light source of a predetermined wavelength  
disposed in the casing, and

the apparatus further comprises a driving  
5 mechanism configured to cause the light radiation  
mechanism to perform horizontal scanning above the  
substrate held by the spin chuck.

[28] A developing apparatus comprising:

a rotatable spin chuck configured to hold a  
10 substrate having a light-exposed resist film disposed  
thereon;

a developing solution/chemical liquid supply  
nozzle configured to mix a developing solution and a  
chemical liquid at a predetermined ratio to form a  
15 mixture liquid, and supply the mixture liquid onto a  
surface of the substrate held by the spin chuck,  
wherein the chemical liquid contains a resist curing  
aid contributory to curing of a resist film remaining  
on the substrate after a developing reaction;

20 a rinsing nozzle configured to supply a rinsing  
liquid onto a surface of the substrate held by the spin  
chuck;

a shifting mechanism configured to move the  
developing solution/chemical liquid nozzle and the  
25 rinsing nozzle relative to the substrate held by the  
spin chuck; and

a light radiation mechanism configured to radiate

light having a predetermined wavelength onto a surface of the substrate held by the spin chuck.

[29] The developing apparatus according to claim 28, wherein the developing solution/chemical liquid supply nozzle comprises a casing elongated in one direction and having therein a first liquid reservoir cell to store the developing solution, a second liquid reservoir cell to store the chemical liquid, and a liquid mixing cell communicating with the first liquid reservoir cell and the second liquid reservoir cell, all of which extend in a longitudinal direction of the casing, and wherein the liquid mixing cell has a discharge port at an lower end to discharge a mixture liquid essentially as a strip, and the mixture liquid comprises the developing solution and the chemical liquid mixed at a predetermined ratio.

[30] The developing apparatus according to claim 29, wherein the light radiation mechanism comprises a casing elongated in one direction and having a slit to radiate light essentially as a strip extending in a longitudinal direction thereof, and a light source of a predetermined wavelength disposed in the casing, and

the casing of the developing solution/chemical liquid supply nozzle and the casing of the light radiation mechanism are integrated in parallel with each other.

[31] A developing apparatus comprising:

a rotatable spin chuck configured to hold a substrate having a light-exposed resist film disposed thereon;

5 a developing solution nozzle configured to supply a predetermined developing solution for developing the resist film onto a surface of the substrate held by the spin chuck;

10 a rinsing liquid/chemical liquid supply nozzle configured to mix a chemical liquid and a rinsing liquid at a predetermined ratio to form a mixture liquid, and supply the mixture liquid onto a surface of the substrate held by the spin chuck, wherein the chemical liquid contains a resist curing aid contributory to curing of a resist film remaining on the substrate after a developing reaction;

15 a shifting mechanism configured to move the developing solution nozzle and the rinsing liquid/chemical liquid nozzle relative to the substrate held by the spin chuck; and

20 a light radiation mechanism configured to radiate light having a predetermined wavelength onto a surface of the substrate held by the spin chuck.

[32] The developing apparatus according to claim 31, wherein the rinsing liquid/chemical liquid nozzle comprises a casing elongated in one direction and having therein a first liquid reservoir cell to store the rinsing liquid, a second liquid reservoir cell to

store the chemical liquid, and a liquid mixing cell communicating with the first liquid reservoir cell and the second liquid reservoir cell, all of which extend in a longitudinal direction of the casing, and wherein the liquid mixing cell has a discharge port at an lower end to deliver a mixture liquid essentially as a strip, and the mixture liquid comprises the rinsing liquid and the chemical liquid mixed at a predetermined ratio.

[33] The developing apparatus according to claim 32, wherein the light radiation mechanism comprises a casing elongated in one direction and having a slit to radiate light essentially as a strip extending in a longitudinal direction thereof, and a light source of a predetermined wavelength disposed in the casing, and

the casing of the rinsing liquid/chemical liquid nozzle and the casing of the light radiation mechanism are integrated in parallel with each other.

[34] The developing apparatus according to any one of claims 28, 29, 31, and 32, wherein the light radiation mechanism has a structure comprising a plurality of light sources arrayed at predetermined intervals lengthwise and breadthwise to uniformly irradiate an entire surface of the substrate held by the spin chuck with light having a predetermined wavelength.

[35] The developing apparatus according to any one of claims 28, 29, 31, and 32, wherein the light

radiation mechanism comprises a casing elongated in one direction and having a slit to radiate light essentially as a strip extending in a longitudinal direction thereof, and a light source of a  
5 predetermined wavelength disposed in the casing, and  
the apparatus further comprises a shifting mechanism configured to move the light radiation mechanism relative to the substrate held by the spin chuck.